2. Reducing Emissions from Electric Power

Electricity Sector

The electric power industry emitted approximately 2,252 million metric tons of carbon dioxide in 1999, 40 percent of total U.S. carbon dioxide emissions. Electric utilities accounted for 1,953 million metric tons (87 percent), and nonutility power producers accounted for 299 million metric tons (13 percent).[19] Carbon dioxide emissions result from the combustion of fossil fuels—coal, oil, and natural gas—during electricity generation. For example, coal, which accounts for 81 percent of electric power industry carbon dioxide emissions, is the primary energy source for U.S. electricity generation and has the highest rate of carbon dioxide emissions per unit of energy used among fossil fuels. When it is burned, coal emits about 70 percent more carbon dioxide per unit of energy consumed than does natural gas.

Between 1990 and 1999, carbon dioxide emissions from the electric power industry increased by 384 million metric tons or 21 percent, a trend that reflects U.S. economic growth and corresponding increases in energy consumption. In 1999, despite a strong economy, carbon dioxide emissions from the electric power industry increased by only 1 percent, from 2,231 million metric tons in 1998 to 2,252 million metric tons in 1999. The slower growth in emissions can be attributed primarily to mild weather in the summer of 1999.

Reported Reductions

In 1999, 453 electric power projects were reported,[20] yielding total reported emission reductions of 123.6 million metric tons carbon dioxide equivalent and an average reported reduction of 272,779 metric tons carbon dioxide equivalent per project (Table 6). Carbon content

Table 6. Number of Electric Power Projects and Emission Reductions Reported by Project Type, Data Years 1998 and 1999

Project Type	Number of Projects Reported		Emission Reductions Reported (Metric Tons Carbon Dioxide Equivalent)			
			Total		Average	
	1998	1999	1998	1999	1998	1999
Carbon Content Reduction	**201**	**221**	**92,809,911**	**103,724,223**	**461,741**	**469,340**
Availability Improvements	29	35	47,212,841	57,999,643	1,628,029	1,657,133
Fuel Switching	49	50	3,819,783	4,502,984	77,955	90,060
Increases in Lower Emitting Capacity	85	94	47,862,185	48,022,866	563,085	510,882
Other Carbon Reduction	53	55	21,876,483	22,925,991	412,764	416,836
Increasing Energy Efficiency	**277**	**260**	**24,756,276**	**23,355,265**	**89,373**	**89,828**
Generation	***192***	***177***	***21,743,017***	***20,325,014***	***113,245***	***114,831***
Efficiency Improvements	172	159	18,476,484	15,097,020	107,421	94,950
Cogeneration and Waste Heat Recovery	20	18	3,266,533	5,227,995	163,327	290,444
Transmission and Distribution	***86***	***84***	***3,023,842***	***3,040,804***	***35,161***	***36,200***
High-Efficiency Transformers	42	39	1,553,891	1,407,820	36,997	36,098
Reconductoring	28	30	1,576,158	1,721,326	56,291	57,378
Distribution Voltage Upgrades	28	30	1,748,252	1,928,928	62,438	64,298
Other Transmission and Distribution	23	21	724,660	919,748	31,507	43,798
Total Electric Power Projects	**448**	**453**	**116,034,180**	**123,568,697**	**259,005**	**272,779**

Note: More than one project type may be assigned to a single project; therefore, the sums of the projects and reductions in each project type category may exceed the total numbers of projects and reductions in the totals and subtotals.

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

[19] Data on U.S. carbon dioxide emissions from electricity generation is taken from the EIA report, *Emissions of Greenhouse Gases in the United States 1999*, DOE/EIA-0573(99) (Washington, DC, October 2000).

[20] More than one project type may be assigned to a single project; therefore, the sums of the projects and reductions in many project type categories exceed the total numbers of projects and reductions reported.

reduction projects were the most numerous in 1999 (221 projects) and produced the most emission reductions (103.7 million metric tons carbon dioxide equivalent). The largest average emission reductions per project were also attributed to carbon content reduction projects, with the project type "availability improvements" averaging 1.7 million metric tons carbon dioxide equivalent per project. The smallest total of emission reductions reported for a project type was for "other transmission and distribution," at 919,748 metric tons carbon dioxide equivalent. The smallest average emission reductions per project were attributed to "high efficiency transformers," at 36,098 metric tons carbon dioxide equivalent per project.

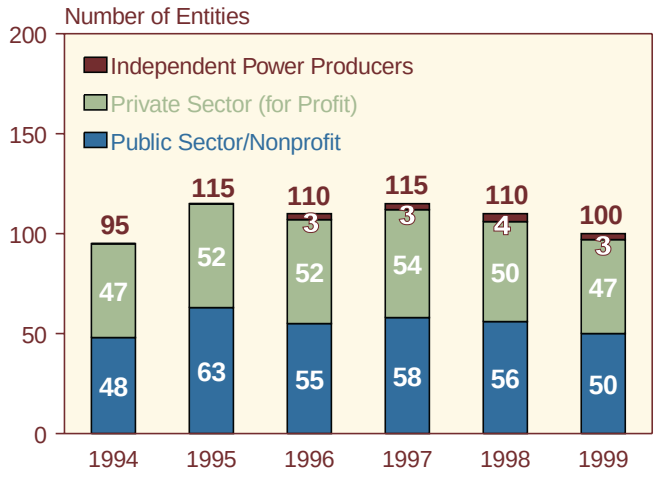
Overview of Projects Reported

For the 1999 reporting year, a total of 100 electric power providers reported to the Voluntary Reporting Program (Figure 4). This is a decrease from the peak of 115 electric power providers reporting in 1995 and 1997 but an increase from the 95 reporters for the first reporting year, 1994. Since 1997, merger activity in the electric power industry as a result of deregulation has reduced the pool of electric utilities reporting to the Voluntary Reporting Program.

Electric power providers make up 52 percent of the total 184 project-level reporters for data year 1999. In the electricity sector, half (50) of the electric power industry reporters were public sector or nonprofit organizations, including electric cooperatives, municipal utilities, and other public-sector entities such as the Tennessee Valley Authority (TVA). Forty-seven entities were private-sector organizations, mostly investor-owned utilities (IOUs). Three were independent power producers (IPPs).

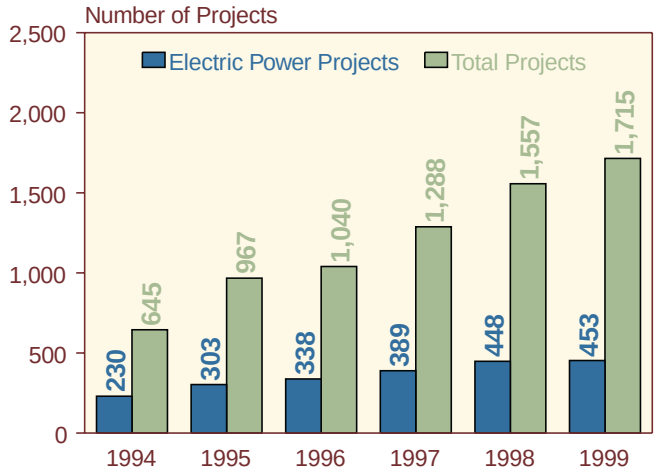
A total of 453 electric power projects were reported for 1999 (Figure 5), a 1-percent increase from the 1998 reporting year total of 448 and a 97-percent increase from the 230 projects reported for 1994. Electric power projects are the most numerous in the Voluntary Reporting Program, accounting for 26 percent of all projects reported for 1999. Electric power projects are reported in a variety of project types. Section 1 projects, those entailing electricity generation, transmission, and distribution, dominate electric power projects with 435 projects, or 96 percent of total electric power projects. Section 1 projects include such activities as fuel switching, heat rate improvements, and reductions in line losses associated with electricity transmission and distribution. Section 2 projects, involving cogeneration and waste heat recovery, accounted for 18 projects or 4 percent of total electric power projects in 1999. In cogeneration and waste heat recovery projects, reporters

Figure 4. Number of Electric Power Reporters by Entity Type, Data Years 1994-1999



Source: Energy Information Administration, Forms EIA-1605 EIA-1605EZ.

Figure 5. Electric Power Projects and Total Projects Reported, Data Years 1994-1999



Source: Energy Information Administration, Forms EIA-1605 EIA-1605EZ.

describe the electricity metering configuration and the end use of thermal energy.

Combined, Section 1 and 2 electric power projects reported reductions equal to 123.6 million metric tons carbon dioxide equivalent, or 55 percent of all project-level greenhouse gas reductions reported under the Voluntary Reporting Program. The reductions reported for electric power projects in 1999 were 6 percent higher than in 1998 and 140 percent higher than in 1994.

Many of the largest projects reported to the Voluntary Reporting Program are electric power projects. In 1999, 25 electric power projects reported reductions of 1 million metric tons carbon dioxide equivalent or more. Electric power projects represented 54 percent of all the projects for which emission reductions over 1 million

metric tons carbon dioxide equivalent were reported, and about two-thirds of those electric power projects were related to nuclear power.

Electric power projects usually reduce emissions in one of two ways. A project may displace higher emitting fossil fuels (e.g., coal) with lower emitting fuels (e.g., natural gas) or with non-emitting renewable (such as hydropower, geothermal, solar, and wind) or nuclear energy sources. Alternatively, a project may improve the efficiency of electricity generation, transmission, and distribution and, thereby, reduce the quantities of fossil fuel used and greenhouse gases emitted by power plants.

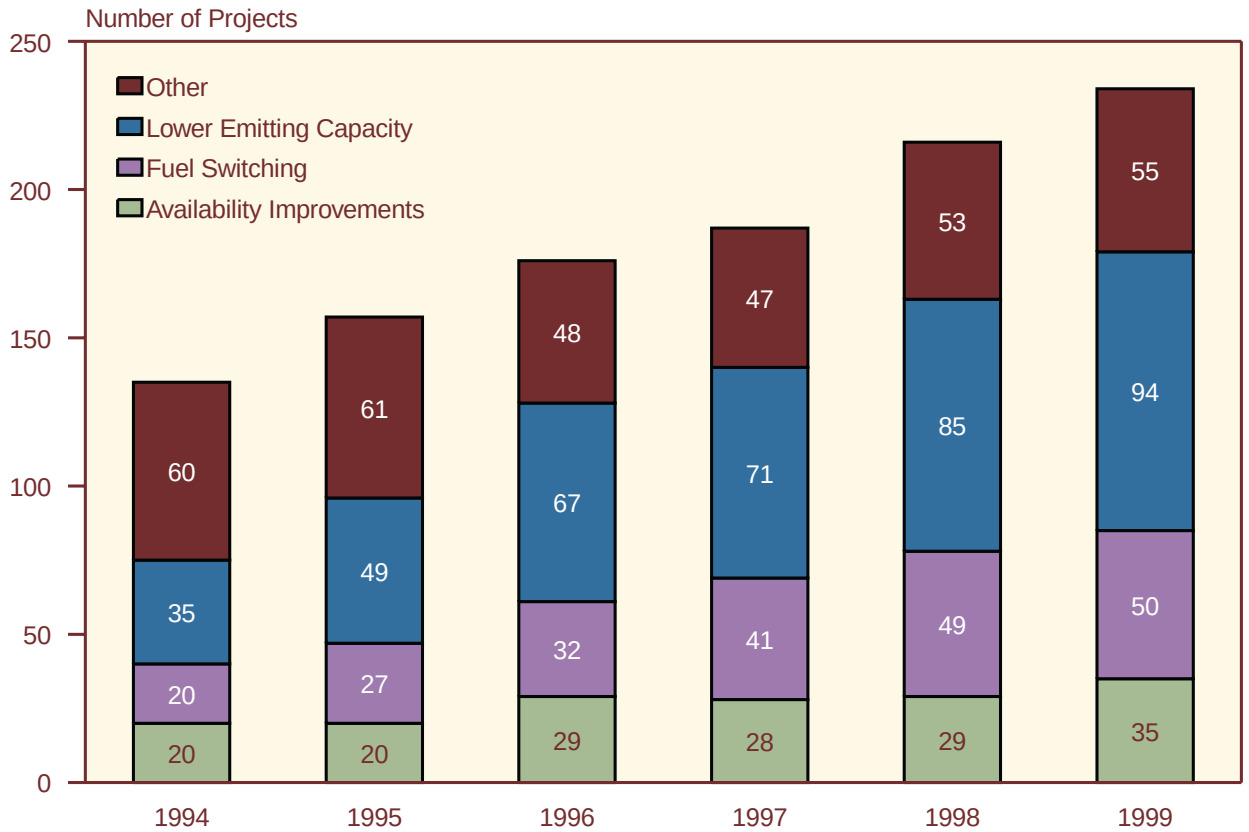
Reducing the Carbon Content of Energy Sources

Fuel-switching projects, power plant availability improvements, increases in low- or zero-emitting generation capacity, and other similar reported projects typically reduce the amount of carbon consumed to generate a unit of electricity. A total of 221 such projects were reported for 1999, including some of the largest projects reported to the Voluntary Reporting Program (Figure 6). The emission reductions reported for "carbon content reduction" electric power projects in 1999 totaled 103.7 million metric tons carbon dioxide equivalent and averaged 469,340 metric tons per project. Some carbon content reduction projects are in fact "hybrids," combining efficiency improvements with measures such as availability improvements or increases in low-emitting capacity (see box on page 16).

Availability Improvements

By increasing generation from lower emitting power plants, availability improvement projects provide a commensurate reduction in the amount of generation supplied by higher emitting plants. The number of availability improvement projects reported for 1999 was 35—6 more than the 29 reported for 1998. Availability improvement projects accounted for reported emission reductions totaling 58 million metric tons carbon dioxide equivalent in 1999. As for previous reporting years, availability improvement projects, especially those undertaken at nuclear facilities, produced some of the largest reductions in carbon dioxide emissions reported for 1999, averaging 1.7 million metric tons carbon

Figure 6. Electric Power Projects Reducing the Carbon Content of Energy Sources by Project Type, Data Years 1994-1999



Note: The sum of projects in many project categories exceeds the total number of projects reported, because more than one project type may be assigned to a single project.

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

Electricity Supply Carbon Reduction Projects: Definitions and Terminology

The combustion of fossil fuels to produce heat for electricity generation causes greenhouse gas emissions. In addition to substantial releases of carbon dioxide, fossil fuel combustion also emits small quantities of methane and nitrous oxide. Carbon content reduction projects typically reduce greenhouse gas emissions by replacing higher emitting fuels (such as coal) with lower emitting fuels (such as natural gas) or non-emitting energy sources (such as nuclear power or renewables). Projects that reduce the carbon content of electricity supply include the following.

Availability Improvements. By reducing the frequency and length of planned and unplanned power plant outages, availability improvement projects can result in increased use of the affected plant. This is particularly true if the plant is a *baseload* plant (i.e., a plant that is generally used on an around-the-clock basis except during plant outages), but it may hold true for other types of plants as well. If the resulting increase in generation from the affected plant displaces generation that otherwise would have been produced by a higher emitting plant, emission reductions will result. Power plant utilization is measured by the plant's *capacity factor*, defined as the ratio of the average load on the plant over a given period to its total capacity. For example, if a 200-megawatt plant operates (on average) at 75 percent of its rated capacity (i.e., at a load of 150 megawatts) over a period of a year, the plant's capacity factor is 75 percent.

Fuel Switching. The amount of carbon contained in fossil fuels and released in the form of carbon dioxide during combustion varies, depending on the type of fuel. Thus, carbon dioxide emissions from a power plant can be reduced by switching from a higher emitting fuel (such as coal) to a lower emitting fuel (such as natural gas).

Increases in Lower Emitting Capacity. By increasing the capacity of an existing lower emitting or non-emitting plant (e.g., a hydroelectric plant), or by constructing new generating capacity (e.g., wind turbines), a utility can reduce or avoid reliance on higher emitting plants. The result will be a reduction in greenhouse gas emissions from the displaced plants.

dioxide equivalent per project. Of the 35 availability improvement projects reported, almost half involved nuclear power plants. Mainly through significant advances in operating, maintenance, and refueling procedures, capacity factors at nuclear plants were increased, displacing some fossil-fuel-based power generation.

Because nuclear power plants are invariably large baseload facilities, even a fairly small improvement in plant availability can lead to a sizable reduction in fossil fuel consumption. For example, TXU Electric operates the two-unit nuclear Comanche Peak Steam Electric Station in Glen Rose, TX. Unit 1 entered commercial operation in August 1990 and Unit 2 in August 1993. Since 1991, TXU has made availability improvements to the two Comanche Peak units, chiefly by extending refueling schedules and shortening refueling outages. The Comanche Peak nuclear units were added to TXU's generation mix to meet increasing demand. Had the units not been completed, an equal amount of electricity generation would have been required from coal-fired generating units. In 1999, TXU reported emission reductions of 17.6 million metric tons of carbon dioxide resulting from decreased use of higher emitting lignite fuel as a result of the 18,090 gigawatthours of nuclear electricity generation at the Comanche Peak station.

In another example of an availability improvement project reported for data year 1999, Lower Colorado River Authority reported on availability improvements in a hydroelectric dam modernization project. The project involved the complete rehabilitation of 13 hydroelectric generation units located at the six dams operated by Lower Colorado River Authority. Rehabilitation included installing new turbines, rewinding generators, and replacing the governor system. Eight units had been completed at the time of the report, with a 16-percent increase in capacity. The estimated costs are $8 million to $10 million per year, or a total of $60 million to $80 million. For 1999, Lower Colorado River Authority reported that the resulting increase in hydroelectricity production reduced its coal consumption by 13,000 short tons and its natural gas consumption by almost 100 million standard cubic feet, with a corresponding total emission reduction of about 28,123 million metric tons of carbon dioxide.

Fuel Switching

Fifty fuel-switching projects were reported in 1999, 1 more than the 49 reported in 1998 and 30 more than the 20 reported in 1994. Sixteen of the projects involved switching to natural gas. Switching from coal or oil to natural gas lowers carbon dioxide emissions because of the lower carbon content of natural gas relative to other fossil fuels. For example, switching from bituminous coal to natural gas can reduce carbon dioxide emissions per unit of energy consumed by approximately 43 percent. Although other reported actions, such as switching from oil to gas, may not lead to reductions of the same magnitude, they also reduce greenhouse gas emissions. The fuel-switching projects reported for 1999 accounted for emission reductions totaling 4.5 million metric tons carbon dioxide equivalent, with an average of 90,060 metric tons per project.

An example of a fuel-switching project is the Roseton Generation Plant in Newburgh, NY, reported by Central Hudson Gas and Electric Corporation (now CH Energy Group, Inc.). Roseton Unit 2 was converted in December 1991 from solely an oil-fired unit to a unit capable of firing either oil or gas or co-firing both fuels, and Unit 1 was similarly converted in May 1992. For 1999, Central Hudson reported emission reductions of 185,066 metric tons of carbon dioxide as a result of its use of 7,188,200 million Btu of natural gas at the Roseton plant, displacing an equivalent amount of residual fuel oil use.

Another example of a fuel-switching project is the Biomass Initiative project reported by NiSource / NIPSCO. In September 1997, NIPSCO conducted tests of biomass fuel handling and co-firing of a mixture of urban waste wood and coal at its Michigan City Generating Station. The procedure consisted of varying fuel blends and load to analyze the impacts of co-firing on efficiency, stability, and emissions. In 1999, NIPSCO conducted additional biomass testing at its 160-megawatt Bailly Generating Station, using 3,597 metric tons of biomass to replace 2,081 metric tons of coal. The total emission reduction reported for the Biomass Initiative project in 1999 was 4,268 metric tons of carbon dioxide.

Increases in Lower Emitting Capacity

Projects involving the construction of new, lower emitting power plants or increases in the capacity of existing lower emitting plants were among the most numerous electricity supply projects reported. A total of 94 such projects were reported for 1999, up from 85 reported for 1998 and 35 for 1994. Most involved the installation of nuclear (22 projects), hydropower (21 projects), solar (15 projects), and wind capacity (19 projects) and other efficiency improvements—all with essentially no greenhouse gas emissions. Emission reductions totaling 48 million metric tons carbon dioxide equivalent were reported for increases in low-emitting capacity projects in 1999, with an average reduction of 510,882 metric tons carbon dioxide equivalent per project.

As an example, Northern States Power Company reported in 1999 an increase of 481,760 megawatthours in generation from wind power, reducing emissions by 489,628 metric tons carbon dioxide equivalent. Northern States Power installed three 65-kilowatt turbines in 1986 near Holland, MN, and in April 1993 awarded a bid to Kenetech, a wind developer based in California, for 25 megawatts of wind power. Kenetech installed 73 turbines, which went into full commercial operation in May 1994 near Lake Benton, MN, on the Buffalo Ridge, the highest documented wind resource in Minnesota. An additional 107 megawatts of capacity was on line as of July 1998. As a result of project construction in 1999, the units have a total of about 270 megawatts generating capacity.

For another example, Sacramento Municipal Utility District's (SMUD) reported on its PV Pioneer program, which is responsible for about one-third of SMUD's overall photovoltaic capacity. PV Pioneer installations generate electricity that is supplied to the SMUD grid, offsetting electric power purchases primarily from gas- and coal-fired generating plants. Since 1993, SMUD has been partnering with its customers who pay an extra monthly "green fee" to host SMUD-owned photovoltaic systems on top of their homes, each about 3 to 4 kilowatts. Further feeding solar electricity into SMUD's grid are commercial rooftop installations, ranging from 4 to 130 kilowatts, and "Solarports," which are parking lot generation systems that can also serve as electric vehicle charging stations. In addition to PV Pioneer, SMUD has installed six substation photovoltaic systems, adding about 1 megawatt in distribution support generation. In 1999, SMUD reported 28 commercial and 421 residential photovoltaic sites, which changed the consumption of 3,544 megawatthours of purchased electricity to photovoltaic energy, reducing emissions by 2,448 metric tons of carbon dioxide.

Other Carbon Reduction Projects

Fifty-five "other carbon reduction" projects were reported for 1999. This category of "other" projects includes projects that decrease high-emitting capacity, make dispatching changes only, or increase low- or zero-emitting capacity. In 1999, 18 projects used low- or zero-emitting power purchases to reduce emissions. This is a new category that was added to the Voluntary Reporting Program in 1998, to classify electric power producer / supplier purchases of power from low- or zero-emitting generation sources for resale, replacing generation or purchases of power from more carbon-intensive generation sources. The 18 low- or zero-emitting purchase projects represent an increase of 300 percent from the 6 projects reported for 1998. Another 10 projects reported for 1999 involved decreases in higher emitting capacity, and three involved changes in the dispatching of power plants. Changes in dispatch order can reduce carbon dioxide emissions if lower emitting plants are used more frequently. For 1999, reported emission reductions from "other carbon reduction" projects totaled 23 million metric tons carbon dioxide equivalent, averaging 416,836 metric tons carbon dioxide equivalent per project.

Baltimore Gas & Electric Company, for example, reported emission reductions of 86,073 metric tons of carbon dioxide from its zero / low-emitting project, "Baltimore RESCO Waste-to-Energy MWh Purchases." This project is a guaranteed purchase of surplus generation capacity from a waste-to-energy (municipal solid waste combustion) plant. The electricity purchases are assumed to displace other mixed fossil generation immediately available in the Baltimore region.

On April 29, 1999, PPL Corporation retired from service and shut down Holtwood SES, a 73-megawatt generating unit fired with anthracite coal, located in Holtwood, PA, on the east bank of the Susquehanna River. The plant had been in service since 1954. Emission reductions of 525,585 metric tons of carbon dioxide were reported as a result of the plant closing, offset by estimated emissions of 218,329 metric tons of carbon dioxide from replacement generation that likely would come from new, lower emitting natural-gas-fired units from the PJM power grid interconnection. Thus, the net emission reduction reported for the project in 1999 was 307,256 metric tons of carbon dioxide.

Increasing Energy Efficiency in Electricity Production and Distribution

Projects involving improvements in the efficiency of electricity generation, transmission, and distribution were more numerous than the other electric power projects reported for 1999 but produced smaller emission reductions on average. Efficiency improvement tends to be an ongoing effort by electric utilities, yielding a continuous stream of small, incremental improvements rather than one-time dramatic increases in efficiency. For example, heat rate improvement projects often are undertaken in response to normal plant deterioration. As power plants age, efficiency tends to erode gradually. Operators seek to maintain heat rates by replacing old, worn-out equipment. Similarly, new energy-efficient transformers are often installed gradually over a period of years, as old transformers fail.

A total of 260 "increasing energy efficiency" projects were reported for 1999, including some "hybrid" projects that combined efficiency improvements with measures such as availability improvements. The efficiency improvement projects fall into two main categories: (1) generation, involving efficiency improvements in the conversion of fossil fuels and other energy sources into electricity; and (2) transmission and distribution, involving improvements in the delivery of electricity from the power plant to the end user (see box on page 19).

Generation Projects

Efficiency Improvements. Improvements in generating efficiency were the most numerous type of efficiency project reported for 1999. A total of 159 such projects were undertaken in 1999, down by 8 percent from the number reported for 1998 but 87 percent higher than the 85 projects reported for 1994. Heat rate improvements at coal-fired power plants are a commonly reported means of increasing efficiency and reducing carbon dioxide emissions. There are numerous opportunities for improving efficiency at existing power plants, but the efficiency gains, and hence reductions in fuel consumption and emissions, are limited by technology and tend to be small. Emission reductions reported for generation efficiency improvement projects in 1999 totaled 15 million metric tons carbon dioxide equivalent, averaging 94,950 metric tons per project.

As an example, American Electric Power reported heat rate improvement activities (projects and operational changes) at its coal-fired power plants in 1999. The improvements reportedly saved 408,000 short tons of bituminous coal, 146,000 short tons of subbituminous coal, and 600,000 cubic feet of natural gas, reducing emissions by 1.2 million metric tons of carbon dioxide.

SeaWest Windpower reported a new project in 1999, Westwinds II, a repowering project that is part of a major renewable energy initiative in the area of the San Gorgonio Pass in California. The project involves the dismantling of old wind turbines from four facilities and replacing them with 62 new NEG Micon wind turbines, each with a capacity of 700 kilowatts, resulting in a total new project capacity of 43.4 megawatts. Expected output from the new facility is 150,602 megawatthours of electricity annually. The emission reductions reported for the project in 1999 were 28,723 metric tons of carbon dioxide, resulting from 52,770 megawatthours of wind-generated power.

Cogeneration and Waste Heat Recovery. A total of 18 cogeneration and waste heat recovery projects were reported in 1999, as compared with 7 projects reported for 1994. Emission reductions reported for cogeneration and waste heat recovery projects in 1999 averaged 290,444 metric tons carbon dioxide equivalent, more than any of the other types of efficiency improvement projects but less than the average for carbon content reduction projects. Industrial partners in the cogeneration projects reported for 1999 include a greenhouse, steel mills, and a heating plant in the Czech Republic. Reported end uses of the thermal energy include electricity generation, process heat applications, and space heating and cooling. The emission reductions reported for cogeneration and waste heat recovery projects in 1999 totaled 5.2 million metric tons carbon dioxide equivalent.

An example of a 1999 cogeneration and waste heat recovery project is a report by the Southern Company. During 1999, Alabama Power Company (part of Southern Company) began operating a new cogeneration facility in Washington County, AL, adjacent to an Olin chemical plant. The cogeneration facility, fired with natural gas and hydrogen, produces both electricity and process steam for the neighboring Olin plant. The facility displaces coal-fired generation with natural gas and introduced hydrogen, a byproduct at the plant, as a fuel. Steam provided from the facility eliminates the need for Olin to produce its own steam from less efficient

Efficiency Projects: Definitions and Terminology

Generation Projects

It is neither theoretically nor practically possible to convert all the thermal or other energy produced by a power plant into electrical energy. In fact, much of the energy is lost rather than converted. Typically, U.S. steam-electric generating plants operate at efficiencies of about 33 percent, meaning that two-thirds of the thermal energy produced is lost. Some more advanced power plants have higher efficiencies, but even new combined-cycle plants (in which the waste heat from a gas turbine is recovered to produce steam to drive a turbine) typically have efficiencies of only 50 to 60 percent. Generation projects seek to improve power plant efficiencies either by reducing the amount of energy lost during the conversion process or by recovering the lost energy for subsequent application.

Efficiency Improvements. By increasing the efficiency of the generation process, efficiency improvement projects at fossil-fuel-fired power plants reduce the plants' *heat rate*, defined as the amount of fossil energy (measured in Btu) needed to produce each kilowatthour of electricity. The result is a reduction in the amount of fuel that must be burned to meet generation requirements, and hence a reduction in carbon dioxide (and other greenhouse gas) emissions. Efficiency improvements at nonfossil (e.g., hydroelectric) power plants can also reduce greenhouse gas emissions. Emission reductions occur if the efficiency improvement leads to an increase in the amount of electricity generated by the affected plant, with a consequent reduction in the amount of electricity that must be generated by other (fossil fuel) plants to meet demand.

Cogeneration. Only a portion of the heat generated during the combustion of fossil fuels can be converted into electrical energy; the remainder is generally lost. Cogeneration involves the recovery of thermal energy for use in subsequent applications. Cogeneration facilities typically employ either topping or bottoming cycles. In a *topping cycle*, thermal energy is first used to produce electricity and then recovered for subsequent applications. Topping cycles are widely used in industry as well as utility power plants that sell electricity and steam to customers. In a *bottoming cycle*, the thermal energy is first used to provide process heat, from which waste heat is subsequently recovered to generate electricity. Bottoming cycle applications are less common, usually associated with high-temperature industrial processes. Because cogeneration involves the recovery and use of thermal energy that would otherwise be wasted, it reduces the amount of fossil fuel that must be burned to meet electrical and thermal energy requirements, hence reducing greenhouse gas emissions.

Transmission and Distribution Projects

The purpose of the electricity transmission and distribution system is to deliver electrical energy from the power plant to the end user. Resistance to the flow of electrical current in cables, transformers, and other components of the transmission and distribution system causes a portion of the energy (typically about 7 percent) to be lost in the form of heat. Improving the efficiency of the various system components can decrease such "line losses," reducing the amount of generation required to meet end-use demand and, thus, power plant fossil fuel consumption and greenhouse gas emissions.

High-Efficiency Transformers. Transformers, used to change the voltage between different segments of the transmission and distribution system, are a major source of system losses. Transformer losses occur as a result of impedance to the flow of current in the transformer windings and because of hysteresis and eddy currents in the steel core of the transformer. When existing transformers are replaced with high-efficiency transformers (including improved silicon steel transformers and amorphous core transformers), losses are reduced.

Reconductoring. Like transformers, conductors (including feeders and transmission lines) are a major source of transmission and distribution system losses. In general, the smaller the diameter of the conductor, the greater its resistance to the flow of electric current and the greater the consequent line losses. Reconductoring involves the replacement of existing conductors with larger diameter conductors.

Distribution Voltage Upgrades. Line losses are dependent, in part, on the voltage at which the various segments of the transmission and distribution system operate. Upgrading the voltage of any segment can reduce line losses.

coal-fired boilers. Also, a portion of the flue gas from the new cogeneration facility is extracted from the stacks and supplied to Olin for use in its carbonization system. Altogether, the reported emission reductions from the project in 1999 were more than 1 million metric tons of carbon dioxide.

Reliant Energy-HL&P owns and operates the San Jacinto Steam Electric Generating Station in La Porte Texas, which includes two combustion turbines with heat recovery steam generators and has a generating capacity of 162 megawatts. The San Jacinto Station improves the generating efficiency of the Reliant Energy-HL&P system and lowers the system carbon dioxide emission rate, resulting in lower overall emissions. San Jacinto also provides process steam to an adjacent DuPont facility, replacing three older and less efficient gas-fired boilers. For 1999, Reliant Energy-HL&P reported emission reductions of just under 1.2 million metric tons carbon dioxide equivalent for the project.

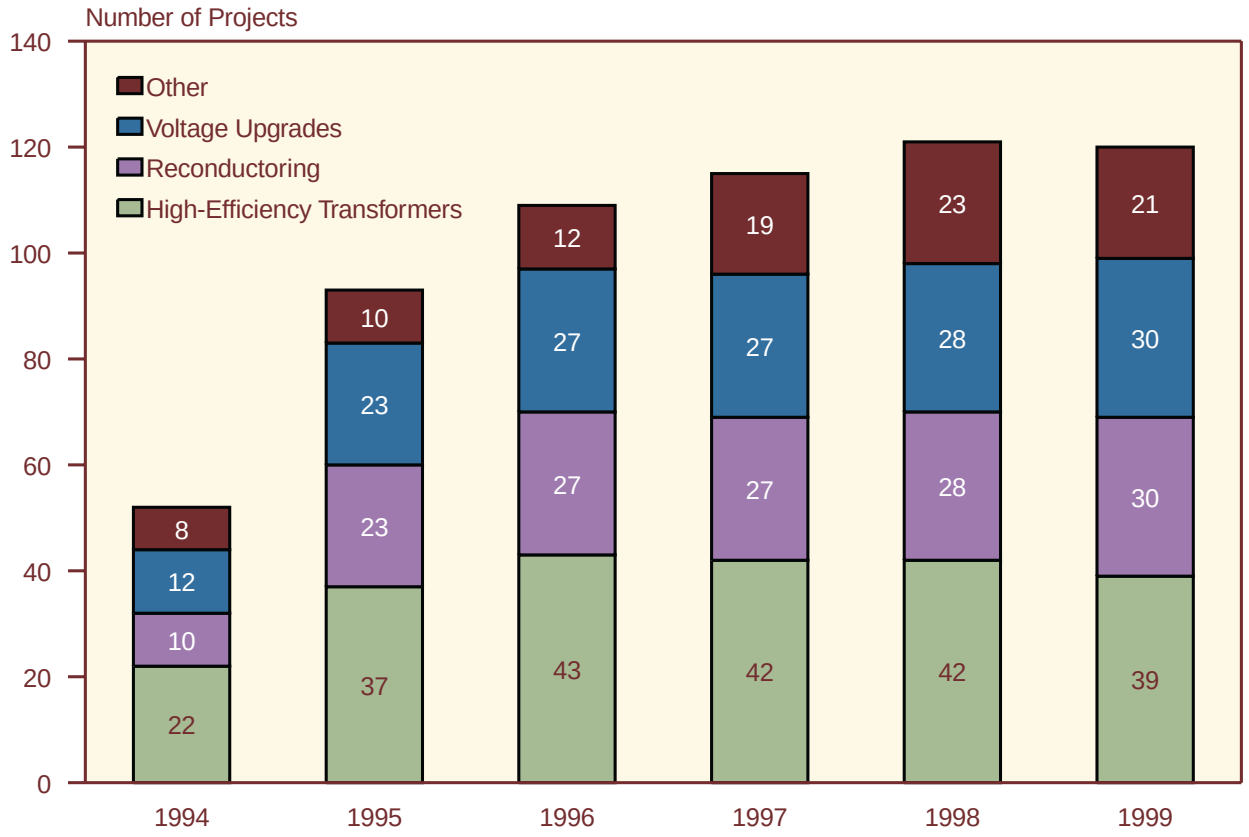
Transmission and Distribution Projects

Transmission and distribution projects, although not as numerous as generation projects, are nonetheless reported in significant numbers. In 1999, 84 transmission and distribution projects were reported, up by 5 percent from 1998 and by 89 percent from 1994. Unlike generation projects, which typically have discrete start and completion dates, efforts such as upgrading conductors and replacing transformers are ongoing activities by electric power providers. Consequently, most of the transmission and distribution efficiency improvements reported for 1999 were reported as continuations of long-standing projects rather than as new projects.

In terms of average emission reductions, transmission and distribution projects typically are somewhat smaller than generation projects. There are numerous opportunities for improving efficiencies in the delivery of electricity, but the magnitude of the efficiency gains that can be realized is limited.

In 1999, the three most frequently reported types of transmission and distribution projects (Figure 7) were high-efficiency transformers (including improved silicon steel and amorphous core transformers); reconductoring (replacing existing conductors with large-diameter conductors to reduce line losses); and

Figure 7. Reported Transmission and Distribution Projects by Type, Data Years 1994-1999



Note: The sum of projects in many project categories exceeds the total number of projects reported, because more than one project type may be assigned to a single project.

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

distribution voltage upgrades (increasing the voltage at which the various segments of the system operate to reduce line losses). Other transmission and distribution projects include general transmission and distribution projects not specific to high-efficiency transformers, reconductoring, or distribution voltage upgrades. For example, transmission line improvements and capacitor installations are considered as general or "Other T&D" projects and are aggregated into the "Other T&D" category for ease of comparison with the larger project categories. A total of 39 high-efficiency transformer projects were reported for 1999 (down from 42 for 1998), making it the most frequently reported type of transmission and distribution project. Many of the reported projects were "hybrids," combining high-efficiency transformer installation with one or more other activities (e.g., reconductoring).

Another 30 projects involving reconductoring and 30 projects involving distribution voltage upgrades (again, often in combination with other activities) were reported for 1999. The reporters classified 21 projects as "general" or "other" transmission and distribution, down from 23 in 1998. Emission reductions reported for transmission and distribution projects in 1999 totaled 3.0 million metric tons carbon dioxide equivalent, averaging 36,200 metric tons carbon dioxide equivalent per project.

As an example, Wisconsin Electric Power Company reported transmission system additions and distribution system projects including high-voltage distribution conversion and system renewal projects, application of distribution capacitors, conservation voltage reduction, and replacement of electromechanical load tap changer controls. Wisconsin Electric reported a savings of 312,183 megawatthours of electricity generation from coal-fired power plants, reducing emissions by 321,778 metric tons of carbon dioxide.

National Grid USA reported in 1999 on a new project of distribution voltage upgrades for Massachusetts Electric. The upgrades for 65.14 miles saved 2,832 megawatthours of electricity, with estimated emission reductions of 1,872 metric tons of carbon dioxide.